

TITLE: A SAFETY GUIDE FOR SPINAL ANESTHESIA

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1. INTRODUCTION

In 1885, Corning reported an experiment of spinal anesthesia (SA) in dogs using cocaine in the US and it was the first description of spinal anesthesia. In 1899, Bier first succeeded in its clinical application in Germany.

In Japan general anesthesia was mainly used early in the Showa era (1920s), but gradually local anesthesia became popular. Spinal anesthesia using tropacocaine diluted with spinal fluid was first performed in 1932. Then, pantocain became widely used for SA in 1933, and it was applied even to gastrectomy in around 1935. Nupercaine became to be used for appendectomy in about 1937. Nupercaine was the drug to be used widely after 1945 (after the World War II). Modern anesthesiology was introduced to Japan from the US at that time and the education and research of anesthesiology became active after that in our country.

It is generally recognized that both patients and the doctors have enjoyed the benefits of SA from its clinical introduction until today. It is true that SA has contributed much to improve medical science and practice in many ways. But we can not deny that many patients have suffered from the tragic accidents of serious complications caused by SA. In Japan, death caused by lumbar spinal anesthesia was already reported in 1927. Many medical textbooks published in late 1950's or later had given many lessons and cautions. For example, descriptions about the complications caused by

SA appear in "A Guide to the Modern Anesthesiology" issued in 1952. It says that we must pay much attention especially to the changes in blood pressure and the pulse rate for about 15 minutes after administering SA. "Practical Anesthesiology" issued in 1956 also says that anesthetics will fix to the nervous tissue between 5 and 30 minutes after subarachnoid injection, so that we must give much attention during that time. If the blood pressure goes down, the following countermeasures such as fluid infusion, oxygen inhalation, and administration of vasopressors should be taken immediately. "The Practical Anesthesia", which was translated and published in 1957, says that lack of understanding of the level of anesthesia causes many accidents in lumbar spinal anesthesia. It also says that you should not overlook circulatory failure or respiratory failure, and you should take the proper countermeasures immediately if you find any. Then we can administer SA more safely.

Various lessons and cautions about the complications of SA have been reported for more than forty years. But why do many of these complications occur repeatedly? Actually there are not enough number of anesthesiologists and many non-specialist physicians are in charge of anesthesia in Japan. This may be one of the reasons. But more serious reasons are that we have not investigated the causes with sincere attitude, that we have not made them known to everyone, and that we have not made an effort to learn from the tragic accidents of the past.

We, the Subcommittee on the Safety of Anesthesia in the Society for the Safety of Medical Practice, have made this "Safety Guide for Spinal Anesthesia" considering the above aspects in order to administer SA safely, effectively and without accidents in every medical facility.

Nothing gives us more pleasure than the expectation that it would help to provide safe spinal anesthesia to the patients.

2. INDICATIONS OF SPINAL ANESTHESIA

Spinal anesthesia is indicated:

- A. When the surgical field is below the fourth thoracic spinal cord (T4: below the breast level according to the dermatome), and when the operation is possible under SA. Generally operation below the hypogastrium is the best indication.
- B. When an endotracheal intubation is preferably avoided, such as upper respiratory tract infection or a lung disease.
- C. When a muscle relaxant is prohibited.
- D. When the patient's spontaneous respiration is preferably maintained.
- E. When the patient's consciousness is preferably maintained above a certain level.

3. CONTRA-INDICATIONS OF SPINAL ANESTHESIA

A. SA is absolutely contra-indicated:

- 1) When the patient has bleeding tendency.

- 2) When the patient is on an anticoagulant drug.
- 3) When the patient has central or peripheral nervous system disease such as brain tumor, subarachnoid hemorrhage, alcoholism, lateral sclerosis, neuritis, infantile paralysis and syphilis.
- 4) When severe loss of circulating blood volume is suspected.
- 5) When the patient is under serious shock.
- 6) When the patient has infection around the puncture site.
- 7) When the patient has serious heart failure due to coronary artery disease or cardiomyopathy.
- 8) When the patient cannot take the position for puncture.

B. SA is relatively contra-indicated:

- 1) When the patient has serious hypertension or hypotension.
(Hemodynamics are likely to change suddenly during SA.)
- 2) When the spinal column is seriously deformed. (It may be difficult to puncture or control the level of anesthesia.)
- 3) When the patient is an infant or a child. (He/she may not be cooperative and cannot be kept still, so that it is difficult to puncture or control the level of anesthesia.)
- 4) When the patient is extremely nervous or has psychosis. (He/she may not be cooperative.)
- 5) When the patient is extremely obese. (It is difficult to puncture or to control the level of anesthesia or to maintain sufficient ventilation in the supine position.)
- 6) When the patient has serious general prostration. (For example when he/she has serious dehydration, anemia or has been sick in bed for long time.)
- 7) When the patient is under latent shock.

- 8) When it is difficult to secure the airway.
- 9) When the operation takes long time.
- 10) When the patient has an obstructive pulmonary disease or a large abdomen caused by tumors, ascites or obesity, and respiratory depression or blood pressure depression is likely to happen.

4. PREMEDICATION

There are two opinions about premedication. One is that premedication should be done basically. The other is that premedicate patients when necessary. Decision should be made carefully whether to premedicate considering merits and demerits. It is important to judge by considering generally the patient's age, general conditions, how much the patient feels anxious and whether he/she has pain. A powerful analgesic or sedative may cause serious complications during or right after the operation.

Nowadays, it is not a substantiated practice to inject a vasopressor drug such as ephedrine intramuscularly before conducting anesthesia to prevent hypotension which is likely to occur after SA.

5. PREPARATION OF INSTRUMENTS AND DRUGS

A. A tray for SA: It is recommended that all instruments are put together on a tray and be sterilized by steam under high pressure before operation to perform aseptic subarachnoid puncture. Otherwise a disposable pre-packed tray set for SA is recommended.

B. Instruments for cardiopulmonary resuscitation such as anesthetic machine and oxygen: It is indispensable to prepare instruments which provide artificial ventilation with pure oxygen and oxygen inhalation for emergencies such as hypotension or respiratory depression. SA should not be provided without them.

C. A set for endotracheal intubation and oral or nasotracheal airways: It is strongly recommended to keep them at hand.

D. It is strongly recommended to keep a suction instrument and catheters at hand.

E. Drugs

1) Vasopressors: There are many kinds of vasopressors like ephedrine, etilefrine, methoxamine, phenylephrine and CarnigenR. Ephedrine, which increases both heart rate and cardiac output, is more suitable than phenylephrine or methoxamine which causes bradycardia and decreases cardiac output. It is strongly recommended to prepare 1

ml of ephedrine (40 mg) diluted with 9 ml of physiological saline (4 mg of ephedrine per 1 ml) in a syringe for intravenous injection.

2) Atropine: It is strongly recommended to keep atropine at hand for serious bradycardia.

3) Sedatives and analgesics: It is recommended to prepare sedatives and analgesics like diazepam, midazolam, pentazocine, and hydroxyzine. These drugs may cause serious complications like respiratory depression and airway obstruction, so the use should be considered with care. It is advised not to use them when the level of anesthesia is high (above T4), when the patient has respiratory depression, hypotension or general prostration, or when he/she is very old. It is strongly recommended to use them after the level of anesthesia is almost fixed.

4) Muscle relaxants: It is recommended to prepare succinylcholine or vecuronium for emergency endotracheal intubation.

5) Intravenous anesthetics: It is recommended to prepare thiopental and the like for emergency endotracheal intubation or for sedation.

6. MONITORING DEVICES

A. A blood pressure monitor (sphygmomanometer): This device is indispensable. It is strongly recommended to use an automatic oscillometric blood pressure monitor when there are not enough manpower in the facilities, or in case of an emergency operation at night. If the automatic sphygmomanometer is equipped with a recorder, it is recommended to keep the recordings.

B. An electrocardiograph: This device is indispensable. It is strongly recommended to record an electrocardiogram in an emergency.

C. A pulse oximeter: This device is indispensable. The selection of a device which shows plethysmograph (pulse wave) is recommended. When an automatic sphygmomanometer and a pulse oximeter are used, it is strongly recommended to confirm the level of the alarm. When the electrocardiograph is used, it is recommended to confirm the alarm level of the highest or the lowest heart rate.

7. SECURING AN INTRAVENOUS INFUSION AND PREOPERATIVE

INFUSION

- A. It is indispensable to secure a venous route with an intravenous indwelling catheter before anesthesia.
- B. It is recommended to use a large-bore indwelling catheter possible to perform quick infusion. A 20G catheter can be used for an adult, but an 18G is preferable.
- C. If the operation is scheduled in the afternoon and the patient has been fasted since last night, it is strongly recommended to administer 10-15 ml/kg of crystalloid solution intravenously in the morning of the operation. When the operation starts in the morning, it is recommended to administer about 10 ml/kg of fluid intravenously prior to the start of anesthesia.
- D. In case of emergency such as acute appendicitis, and if the patient has high fever or vomiting, or if he/she has been fasted for more than twelve hours, it is strongly recommended to administer at least 10 ml/kg of intravenous fluid prior to anesthesia. It is important to be very careful about the speed and the content of infusion in the following cases; when the patient is an elementary or a junior high school student, when he/she is very old, or when he/she has diabetes mellitus, general prostration or any abnormalities with the cardiovascular system.

8. PUNCTURE POSITION AND SITE

- A. The puncture position should be properly chosen according to the operating site, the operating position, the level of anesthesia, and the specific gravity of a local anesthetic. Generally lateral position is chosen, but sometimes sitting or prone position is selected for puncture.
- B. When the lateral position is selected, the operating table should be set horizontal first. Then, adjust it to keep the spinal column horizontal. Finally, the position should be adjusted considering the puncture site, the specific gravity, or the volume of the local anesthetic, and the desired level of anesthesia.
- C. It is recommended to select a puncture site where the cauda equina is present. In the case of an adult, the lower end of the spinal cord forms a cone at the L1 or L2 of the lumbar vertebra and cauda equina is formed caudal to it. The suitable site for puncture is the intervertebral space below the second lumbar vertebra. The L3 and L4 interspace is usually chosen, but sometimes between L2 and L3, or L4 and L5.
- D. The median approach or the paramedian approach (0.5 cm to 1.0 cm away from the median line) is used. The latter approach may be selected when the former approach is difficult because of the deformity of the body of vertebra, old age, the ossified supraspinatus ligament, or calcified interspinous ligament.

9. SIZE OF SPINAL NEEDLE AND THE APPROACH OF PUNCTURE

- A. The rate of post-spinal headache is reported to be related the size of a spinal needle; the smaller the needle diameter, the lower the rate. So it is recommended to use a 25G or smaller needle such as 27G and 29G. (The rate of post-spinal headache is below 0.1% with a 25G needle).
- B. A 25G needle may be inserted straight without a guide needle. But it is recommended to use a

guide, when using a smaller size needle. In the latter case, a guide needle is inserted into the extradural space first, then a smaller size needle (less than 25G) is inserted through the guide into the subarachnoid space.

C. It is recommended to give local infiltration anesthesia at the puncture site with a very small disposable needle like 27G. First, make an intradermic papule by a local anesthetic like procaine or lidocaine, then let the local anesthetic infiltrate into the subcutaneous tissue and around the supraspinous ligament.

D. When inserting the spinal needle, first hold the needle with one hand, let it go straight until it is fixed in the interspinous ligament, and confirm that it is inserted horizontally by checking from the side. Then, hold the head of the needle with both hands, let it go straight farther slowly. Remind that the arms of the anesthetist be attached to the sides of his/her chest then. Pull out the stilet once just before the needle is supposed to be in the subarachnoid space, and confirm that the cerebrospinal fluid doesn't flow out yet. After that, return the stilet to the former place and let the needle go farther slowly and gradually. After repeating these processes for two or three times, the subarachnoid space will be reached, and then the cerebrospinal fluid flows out. The spinal needle should not be inserted with one hand into the subarachnoid space at a stretch, however well the anesthetist is accustomed to the maneuver. The flow of fluid does not always mean that the bevel of the needle is completely in the subarachnoid space. So that, turn the needle slowly 90-180 degrees right/left to confirm that cerebrospinal fluid flows out in all directions. Rotating the needle 360 degrees is not necessary. Then, inject the local anesthetic.

10. EXAMINATION OF CEREBROSPINAL FLUID

A. It is indispensable to inspect the characteristics of the cerebrospinal fluid flowing out from the needle.

B. The normal cerebrospinal fluid is clear and watery. If it shows xanthochromia (yellowish color), old intracerebral or subarachnoid hemorrhage, a brain tumor or a spinal tumor is suspected. In the case of fresh bleeding, which is often found in subarachnoid hemorrhage, the fluid is equally sanguineous.

C. Sometimes the cerebrospinal fluid flows out mixed with blood. It will gradually turn to be clear usually within several or ten or more drops, when the blood vessel is injured during puncture. When it will not become clear, it is necessary to judge whether it is sanguineous spinal fluid or real blood. Most of the cases, it is not so difficult to judge from the color, viscosity or speed of the flow. Sometimes it is of help to drop it on the forearm of the anesthetist and judge it.

D. When the blood comes from the injured blood vessel during puncture, the fluid is unequally sanguineous and the supernatant fluid usually becomes clear after centrifugation. When the fluid is really sanguineous, it is equally sanguineous and with centrifugation the supernatant fluid shows yellowish or reddish yellow color. The differential diagnosis may be possible by centrifugation and examination of hematocrit, hemoglobin and other elements of the fluid.

E. When it is suspected that the blood flows out because of injury to a blood vessel during puncture, pull out the needle immediately, change to a new needle, if possible, and insert again. It may be necessary to change the puncture site or to ask for another anesthetist to take charge depending on the circumstances.

F. When the sanguineous fluid continues to flow out, after three or four trials, it is strongly

recommended to differentiate the causes. At the same time it is also strongly recommended to examine if there are symptoms indicating subarachnoid hemorrhage.

G. When any abnormality with the cerebrospinal fluid is found, decision should be made whether to operate without SA. Generally, it is strongly recommended to postpone the operation to give precedence to a thorough neurological examination except in an extremely emergency operation case.

11. LOCAL ANESTHETIC AGENTS; TYPES, VOLUME, AND SPEED OF INJECTION

A. There are many kinds of local anesthetics such as dibucaine, tetracaine, lidocaine, and mepivacaine. Dibucaine and tetracaine are mainly used in Japan. It is important to decide carefully how much to give according to the following; the patient's age, weight, height, sitting height, physique, the site of operation, technique, the length of operation, and the operator's ability. Also the combined use of other anesthetics is taken into consideration. It is difficult to calculate how much to give from the weight or the height of the patient. When the patient is extremely obese such as a pregnant woman or a sumo wrestler, the level of anesthesia may sometimes rise much higher than expected. It is important to keep in mind where the target of the level of anesthesia is.

B. The speed of injection of a local anesthetic usually is about 10 sec/ml. The speed is adjusted, of course, according to the desired level of anesthesia, the volume, and the specific gravity of the anesthetic, or the degree of inclination of the operating table. It is strongly recommended to double-check the anesthetic before use.

C. The patient is usually placed in the supine or prone position right after injecting a local anesthetic. There are some cases when the patient is kept in the same position after puncture for 3-5 minutes, for example, operation of a unilateral leg or in the case of saddle-block anesthesia. When the operation is done in a special position, it is recommended to change the position, after having examined the level and the effect of anesthesia.

12. FIXATION TIME OF LOCAL ANESTHETICS, EXAMINATION OF THE LEVEL OF ANESTHESIA, AND EVALUATION OF THE LEVEL OF ANESTHESIA

A. The following factors may influence the level of anesthesia: the content, density, volume and specific gravity of anesthetics, the speed of injection, the puncture site, the position during and after anesthesia, the inclination of an operating table, the direction of a bevel, barbotage, pH of the cerebrospinal fluid, and the change of cerebrospinal fluid pressure caused by a cough, labor pains or deep breathing. Babotage is the technique of anesthesia in which cerebrospinal fluid and the anesthetic are mixed and pumped in and out of the subarachnoid space before complete injection.

B. In 15-20 minutes after injection of a local anesthetic into the subarachnoid space, the level of anesthesia is fixed to a certain degree. However, it is reported that it takes 40-50 minutes to fix finally. So the level of anesthesia should be examined frequently. It is strongly recommended to examine the level of anesthesia at 5, 10, 15 and, if possible, 30 and 60 minutes after injection. It is also strongly recommended to check it at the end of operation and at an emergency such as serious hypotension or respiratory depression. Even if it is difficult to check the level of anesthesia during the operation, it is recommended to examine frequently whether the highest level of anesthesia goes up to T4. It is strongly recommended to check the level of anesthesia within 3 minutes after

injecting a local anesthetic, when the following conditions occur: the sudden blood pressure decrease, the level of anesthesia rises considerably high (above T4) in a short duration, and occurrence of respiratory depression. These may occur, for example, in a caesarean section, in the case of a giant tumor of the abdomen, morbid obesity, or when the patient is an elementary or junior high school student.

C. There are two ways to examine the level of anesthesia. One is to rub the skin with cotton soaked with ethyl alcohol, then check whether the patient feels cold sensation or not. The area at which the patient does not feel cold is nearly the same as the sympathetic blockade area, and is two to several segments wider than the area of analgesia. The other way is to prick the skin slightly with a blunt needle, and check whether the patient feels tenderness or not (the pin prick test). It is important, of course, to check precisely where the highest level of anesthesia is. We often hear the cases in which the highest level is not confirmed.

D. The effect of anesthesia should be evaluated as well as the level of anesthesia. If the effect of anesthesia is considered not adequate, addition of analgesics is first taken into consideration. Then, re-trial of SA or other measures such as general anesthesia is carefully considered. If SA is considered to have insufficient effect in a laparotomy case, it is often much safer to switch to general anesthesia from the beginning instead of giving analgesics several times. It is recommended to plan countermeasures beforehand when the effect of SA is inadequate.

13. TIME OF START OF OPERATION AFTER SPINAL ANESTHESIA

It takes 10-15 minutes before a local anesthetic, injected into the subarachnoid cavity, adsorbs to the nerve fibers and begins to work. So it is strongly recommended to wait for at least 10 minutes, if possible 15 minutes, before starting the operation, except for an extremely emergency operation such as a caesarean section. It is important to take this period as a time to check the vital signs and the level of anesthesia frequently. This warning has been said for more than 40 years, but often not to be kept.

14. FREQUENCY AND INTERVALS OF THE BLOOD PRESSURE MEASUREMENT

DURING ANESTHESIA

A. It is difficult to prescribe the frequency and the intervals of the blood pressure measurement during anesthesia. Keeping in mind that anesthesia is a considerably risky medical practice and from the standpoint "to prevent serious complications caused by spinal anesthesia", it is reasonable to make a rule (standard) of blood pressure measurement, and keep it to a certain extent. We believe the above concept fits the idea of "safety". Accordingly it is strongly recommended to keep the following rule of blood pressure measurement during anesthesia.

1) Measure blood pressure one minute after injecting a local anesthetic. 2) Within 14 minutes after that, measure every 2 minutes. If an

automatic sphygmomanometer, in which the measurement interval

cannot be set at 2 minutes, is used, every two and a half minutes is

permitted. In the case of emergency, such as sudden blood pressure

decrease, blood pressure should be measured continually (stat mode).

- 3) From 15 minutes after injection, measure every 2.5-5 minutes.
- 4) When the symptoms suspecting blood pressure depression, such as yawning, bradycardia and nausea appear, measure on all such occasions.
- 5) Measure every time when a vasopressor drug is given, the patient's position is changed, respiratory depression is noticed, the level of consciousness goes down, or the patient suddenly gets mute.
- 6) Measure when the operation is finished, at the time of return to the ward, and every 30 minutes until the effect of anesthesia wears off completely.

15. EXAMINATION OF HEAR RATE, RESPIRATION AND THE LEVEL OF CONSCIOUSNESS

A. Decrease of the heart rate (bradycardia), is a dangerous indicator of the following conditions; profound hypotension due to the preganglionic sympathetic blockade of T1-T4 fibers and inhibition of the cardioaccelerator nerve, vagal reflex, severe pain due to inadequate analgesia, and profound hypoxia. If serious bradycardia occurs, operation should be stopped to investigate the cause, and proper treatment such as administration of ephedrine, atropine or oxygen inhalation should be instituted as soon as possible to keep the heart rate above 40 per minute.

B. It is said that serious respiratory depression or apnea (respiratory arrest) happens mainly because the medullary respiratory center does not function well, secondary to hypoxia in the brain stem caused by profound hypotension. Local anesthetics seldom go up and inhibit the brain stem directly in ordinary SA. The anesthetic level also seldom rises to paralyze diaphragm. But there may be a case that it goes up to the upper thoracic spinal or the cervical spinal cord level and paralyzes the intercostals or the diaphragm, when too much anesthetics are given, or when the patient moves violently or the patient's position is changed to an extreme head down tilt right after injection of a local anesthetic. Usually paralysis of intercostals alone, between T1 and T12 levels, does not affect tidal volume or respiratory rate, and does not cause serious ventilatory insufficiency, but it depends on circumstances. The patient may often complain of being suffocating because he/she finds difficulty in breathing deeply and feels anxious.

C. When the patient complains that he/she cannot raise his/her voice easily or his/her fingers are numb, high spinal anesthesia is suspected, and the level of anesthesia should be confirmed. Also the presence of respiratory depression should be watched carefully.

D. Respiratory depression sometimes happens when too much premedication, intraoperative analgesics or sedatives are used. When morphine, meperidine, fentanyl, pentazocine, diazepam, or midazolam is administered to an elderly, a child, a person who has serious general prostration, or

an obese person, respiratory depression and airway obstruction should be observed carefully.

E. The factors such as sedatives or analgesics premedicated or given during operation, the level of anesthesia, hypotension or hypoxia affect the level of consciousness during SA. Usually the level of consciousness deteriorates secondary to high level of anesthesia above T4, hypotension which reduces cerebral blood flow, or hypoxia. It is important to talk to the patient or to observe his/her expression continually so as not to overlook deterioration of consciousness level. Therefore, it is very dangerous to cover the patient's face with a drape during the operation. When the patient is snoring, you do not have to wake him/her up so far as blood pressure and respiration are stable, and the level of anesthesia does not rise so high and anesthesia has a sufficient effect. When an elderly patient begins to snore after giving diazepam or midazolam, airway obstruction and respiratory arrest should be watched carefully.

F. When anesthesia is adequate and the patient does not feel dyspnea or nausea, it is not necessary to give a sedative whether premedication was given or not, because he/she often feels sleepy anyway. When diazepam or midazolam is indicated, give 1 mg of the drug dose first and confirm the effect, then give the same amount again if necessary and observe the effect. To give 5 mg at one time may cause an accident.

G. In case that no anesthetist is available on the patient's head, it is strongly recommended to allocate a person (nurse) who is in charge of observing monitoring devices and vital signs of the patient.

16. TREATMENT FOR HYPOTENSION

The basic treatments for hypotension are to give vasopressors, rapid fluid infusion, oxygen and/or atropine administration, elevation of the lower extremities, and putting the patient to the supine position again. There are many opinions as to when the treatment such as administering a vasopressor should be started. The followings are some of the opinions.

- 1) Start the treatment when the blood pressure goes down below 75% of the preoperative value.
- 2) Do not let the systolic blood pressure go down to 70% of the preoperative value.
- 3) The treatment is not necessary if the blood pressure is stable around 70% of the preoperative value.
- 4) Give a small dose of vasopressor when the systolic blood pressure goes down to about 2/3 of the preoperative value.
- 5) Give a small dose of ephedrine (about 5 mg) when the systolic blood pressure goes down to about 80% of the preoperative value.
- 6) Take the proper treatment if the blood pressure goes down to 90% of

the preoperative value within the first two minutes.

7) Maintain the systolic blood pressure above 100 mmHg in any circumstances.

There are many other opinions in addition to the above. Basically it is recommended to treat according to the following rules.

A. When the systolic blood pressure goes down to $\frac{3}{4}$ of the value before anesthesia, (because the blood pressure usually rises a little above the patient's usual value from anxiety or tension when he/she enters the operating room), the speed of infusion is increased and ephedrine 4-5mg should be given intravenously.

B. Measure blood pressure 20-30 seconds after giving ephedrine. If the blood pressure does not increase, give 4-5 mg of ephedrine again. Repeat this procedure so as not to decrease the blood pressure further.

C. When the heart rate decreases besides hypotension, consider to inject 0.25 to 0.5 mg of atropine intravenously. The heart rate below 50 per minute should be considered the lower threshold for an adult, but it depends on the rate before anesthesia. If the heart rate increases after administration of ephedrine, wait a little to observe the change. Be careful not to decrease the heart rate below 40 per minute.

D. If the blood pressure does not increase in spite of giving a vasopressor, countermeasures such as rapid fluid infusion by pumping through the three-way stopcock, raising both legs, administration of oxygen, or putting the patient into Trendelenburg position should be instituted. The head down position may be claimed to raise the level of anesthesia and reduce the blood pressure further, but the level of anesthesia rises only 2-3 segments of the spinal cord. So that when rapid increase in blood pressure is anticipated secondary to an increase in venous return, adopt the head down position for a while.

E. When the supine hypotension syndrome occurs, try to increase the blood pressure by releasing the aorto-caval compression through the left-sided tilt of the operating table, or elevation of the pregnant uterus or intraabdominal tumor. There are some cases in which delivery of a fetus is most expedited in a caesarean section.

F. When the blood pressure does not increase easily, in spite of giving vasopressors or infusion, dopamine at a speed of 5-10 microgram/kg/minute is given continuously.

G. The above treatment is sufficient for most of the hypotension cases. In case of delay in detecting hypotension or bradycardia, or when the patient develops respiratory depression and/or unconsciousness combined with hypotension, he/she sometimes falls into the condition of cardiopulmonary arrest. More than 99% of the cases of so-called spinal shock (Lumbarchock) are caused by a rapid rise in the level of spinal block, resulting in marked circulatory depression, respiratory depression or cardiopulmonary arrest. Of course anaphylaxis should be kept in mind, but it is extremely rare (1 in 1,000,000 anesthetics).

H. If the patient is judged to be in cardiopulmonary arrest, effective cardiopulmonary cerebral resuscitation should be instituted immediately to prevent hypoxic brain damage. The details are shown in the specialized textbooks, but the basic ways of resuscitation are to open an airway (to prevent hypopharyngeal obstruction by flexing the head backward and raising the mandible), to keep an airway (endotracheal intubation), to give artificial respiration (high concentration oxygen inhalation), to maintain circulation (external cardiac massage and securing a venous route), to give drugs, and to give cardioversion against ventricular fibrillation (cf. Table 1). It is emphasized again that preparation of the instruments and drugs beforehand is mandatory for successful resuscitation.

17. TREATMENT OF RESPIRATORY DEPRESSION

A. When the patient complains that he/she feels suffocating, difficulty in breathing, pain in the chest or difficulty in phonation during SA, it is mandatory to immediately measure the blood pressure, the level of anesthesia, and whether he/she can breathe deeply. If a pulse oximeter is in use, check the value of SaO₂. When hypotension is observed, take measures to raise the blood pressure. When the level of anesthesia is below T4, let the patient be relaxed and breathe deeply first. Then, if he/she keeps a sufficient tidal volume in spite of his/her difficulty in deep breathing, tell him/her to breathe slowly and quietly to avoid hyperventilation. When the level of anesthesia rises rapidly, the patient sometimes feels severe dyspnea even when the level is below T4 and falls into a serious condition from anxiety or fears, shaking his/her head. In this case, tell him/her to calm down and also make him/her inhale about 3L/minute of oxygen in stead of scolding loudly.

B. When the level of anesthesia goes up above T2 and the tidal volume decreases a little, it is important to let the patient feel assured first by saying to him/her, "Do not worry if you feel suffocating, when you really come to be unable to breathe we provide you artificial respiration." Then, start 4-6 L/minute of oxygen from the anesthesia machine, put a mask on the patient's face and try assisted ventilation by pressing the bag slightly with every third of his/her spontaneous respiration. Insertion of an airway is not necessary. Ventilation should be smooth when the level of anesthesia goes up to about T1. However, the anesthetist should be accustomed to the technique of artificial ventilation with a mask and a bag so as to provide it effectively with the spontaneous respiration in place. The knack is to press the bag gently, and never press it hard. When the spontaneous respiration stops during artificial ventilation, which sometimes happens, keep providing artificial ventilation 10-15 times per minute. Of course instruments and drugs to practice endotracheal intubation should be prepared, but there are many cases in which endotracheal intubation is not necessary so long as artificial ventilation with a mask and a bag is possible, although it depends on the operating site or the technique. Usually the patient resumes

spontaneous respiration in 20-40 minutes. When the judgement is made to practice endotracheal intubation, stop the operation and give necessary drugs, then make intubation carefully.

C. Inappropriate use of narcotics or sedatives to an elderly patient or a patient who has a serious general prostration may cause respiratory arrest. It is very important to find respiratory depression or arrest as early as possible. This principle is the same as the case of hypotension. Avoid the situation where the patient has already had serious cyanosis, bradycardia or even cardiac arrest when noticed. Therefore it is strongly recommended that the person who is in charge of checking the vital signs should stand on the patient's head, check the complexion, expression and the pattern of respiration and sometimes talk to him/her to observe his/her response. If anesthetist who is entirely in charge of anesthesia is not in the room, the designated person should report the changes to the surgeon in charge of the operation.

18. RECORDING OF THE ANESTHESIA CHART

It is indispensable to record the anesthesia chart. It is strongly recommended to start the recording when the first blood pressure is measured after the patient's admission to the operating room.

19. SUMMARY

It is needless to say that prevention of complications is utmost importance. Physicians and nurses who are in charge of SA must know very precisely about the indications and contra-indications, merits and demerits, possible complications, and the preventive measures and countermeasures. Although issues relating to the selection of the types of anesthesia are not described in the text, it is necessary to decide them carefully according to the items shown in the Appendix.

20. APPENDIX

To perform safe and effective SA:

A. The principal items of SA:

- 1) Inform SA sufficiently to the patient, let him/her understand the feature and the importance of anesthesia, and obtain his/her consent and cooperation.
- 2) The patient is able to endure the operation under SA mentally and physically.
- 3) The surgeon should know SA well and should have the ability to perform the operation under SA.
- 4) The physician in charge of anesthesia and the nurses who work in the operating room should know SA well.
- 5) The physician in charge of anesthesia should have a reliable skill.

6) Prepare for the prevention and treatment of serious complications.

7) Even if the operation finishes in a short time, leave the patient in the operating room or in the recovery room for at least an hour after SA and observe the general condition.

8) Do not schedule the operation which is not practicable because of insufficient manpower or time.

9) If an operation is intended during the time when the shortness of manpower is expected, for example in the midnight or on holidays, emergency operation system should be established beforehand.

Maintenance of the monitoring devices are especially important.

10) Anesthesia record should be kept on every anesthesia.

B. The common features seen in patients with serious complications of SA:

1) The serious complications occur frequently in seemingly rather easy operations, such as appendectomy or repair of inguinal hernia, which is not always easy in reality.

2) In many cases the patients are in their teens, especially in the age of puberty.

3) Physician, who is not anesthesiologist, performs SA. Soon after injecting a local anesthetic into the subarachnoid space, the same physician scrubs his/her hands and acts as operator or assistant.

4) An electrocardiograph is not monitored.

5) The patient's past history, laboratory tests, the time when he/she has eaten and drunk last, have not been checked before the operation.

6) Preoperative management of the patient is lacking. Especially the patient does not get infusion at all or sufficiently before anesthesia,

and seems to be under mild or moderate dehydration.

7) There are not any doctors or nurses who are responsible for watching the patient's blood pressure, respiration, and the level of consciousness during and after the operation.

8) Measurement of the blood pressure is not done frequently (every one or two minutes) after SA.

9) Measurement of blood pressure, heart rate and the level of consciousness is not done at all for about 5 minutes before the occurrence of respiratory arrest or cardiac arrest.

10) The patient has already fallen into cyanosis, respiratory arrest, profound hypotension, or cardiac arrest when the emergency condition is noticed.

11) The surgeon starts the operation within 10 minutes after injecting a local anesthetic into the subarachnoid space.

12) The level of anesthesia is not checked frequently, usually only one time just before starting the operation.

13) Preparation for emergency, such as artificial ventilation, endotracheal intubation and drugs is insufficient.

14) Cardiopulmonary resuscitation is not done immediately and correctly.

15) The patient is transferred to the stretcher, put clothes on, and let him/her return to the ward right after the operation without considering the duration of anesthesia or operation.

16) The anesthesia chart is not recorded correctly.

All items above-listed do not always apply in all complications, but such features can be found in many of the cases. It is clear that by considering these common features, administration of SA may become safe without serious complications.

C. The environment and/or factors causing anesthetic accidents (errors and mishaps).

- 1) Fatigue.
- 2) Insufficient maintenance of the devices.
- 3) Inappropriate environment of the operating room: location, lighting, atmosphere, temperature, noise, stress, and arrangement of the devices.
- 4) Inappropriate communication and cooperation
- 5) Busyness
- 6) Improper clinical experience
- 7) Absence of anesthetists or the person who is entirely in charge of observing the monitors or checking the vital signs.
- 8) Over-confidence in the monitors.
- 9) Lack of tension/boredom.

D. The ability required to avoid errors and accidents

- 1) Attentiveness
- 2) Judgment
- 3) Concentration power
- 4) Reasoning
- 5) Ability to act
- 6) Perseverance
- 7) Decision
- 8) Tenacity
- 9) Ability to think from the broader view
- 10) Cooperativeness
- 11) Attitude to check mistakes

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